

14  
Report SAM-TR-78-33

2 NW  
LEVEL

6  
FIGHTER INDEX OF THERMAL STRESS: RELATION  
TO WEATHER CONDITIONS AT ATC AND TAC BASES.

10  
Sarah A. Nunneley M.D.  
Richard F. Stribley Captain, USAF, BSC

AD A062713  
THIS DOCUMENT IS BEST QUALITY PRACTICAL.  
THE COPY FURNISHED TO DDC CONTAINED A  
SIGNIFICANT NUMBER OF PAGES WHICH DO NOT  
REPRODUCE LEGIBLY.

DDC  
DEC 29 1978  
RESOLVED  
F

11  
November 1978

12 25p  
9  
Interim Report, for period: Sept 1977 - Sept 1978

Approved for public release; distribution unlimited.

16 1730  
17 14  
DDC FILE COPY  
USAF SCHOOL OF AEROSPACE MEDICINE  
Aerospace Medical Division (AFSC)  
Brooks Air Force Base, Texas 78235



31 1 000 78 12 26 00.8 1072

## NOTICES

This interim report was submitted by personnel of the Crew Protection Branch, Crew Technology Division, USAF School of Aerospace Medicine, AFSC, Brooks Air Force Base, Texas, under job order 7930-14-04.

When U.S. Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

*Sarah A. Nunneley*  
SARAH A. NUNNELEY, M.D.  
Project Scientist

*William J. Sears*  
WILLIAM J. SEARS, Lt Col, USAF, BSC  
Supervisor

*L. J. Enders*  
LAWRENCE J. ENDERS  
Colonel, USAF, MC  
Commander

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE   |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM  |
|---|-----------------------|--|
| 1. REPORT NUMBER<br>SAM-TR-78-33 ✓  | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER  |
| 4. TITLE (and Subtitle)<br><br>FIGHTER INDEX OF THERMAL STRESS: RELATION TO<br>WEATHER CONDITIONS AT ATC AND TAC BASES  |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Interim Report<br>Sep 77 - Sep 78                    |
|   |                       | 6. PERFORMING ORG. REPORT NUMBER   |
| 7. AUTHOR(s)<br>Sarah A. Nunneley, M.D.<br>Richard F. Stribley, Capt, USAF, BSC   |                       | 8. CONTRACT OR GRANT NUMBER(s)   |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>USAF School of Aerospace Medicine (VNT) ✓<br>Aerospace Medical Division (AFSC)<br>Brooks Air Force Base, Texas 78235   |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br><br>62202F<br>7930-14-04 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>USAF School of Aerospace Medicine (VNT)<br>Aerospace Medical Division (AFSC)<br>Brooks Air Force Base, Texas 78235   |                       | 12. REPORT DATE<br>November 1978   |
|   |                       | 13. NUMBER OF PAGES<br>22  |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)   |                       | 15. SECURITY CLASS. (of this report)<br><br>UNCLASSIFIED                                   |
|   |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE  |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.   |                       |  |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)  |                       |  |
| 18. SUPPLEMENTARY NOTES   |                       |  |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Thermal stress<br>Heat stress<br>Heat-stress index<br>Heat  |                       |  |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Fighter Index of Thermal Stress (FITS) is a tool recently developed for minimizing hazardous aircrew heat stress during hot-weather operations. The FITS table, entered with ground dry bulb temperature ( $T_{db}$ ) and dewpoint temperature ( $T_{dp}$ ), yields a numerical estimate of cockpit heat stress. Superimposed on the table are Normal, Caution, and Danger Zones, with footnotes recommending appropriate precautions. This report examines the relationship of FITS to typical weather conditions at 30 ATC and TAC bases in the continental United States. An appendix presents a graph for each base, indicating the frequency of readings in the Caution and Danger Zones for each hour of the day and month of the year. |                       |  |

DD FORM 1 JAN 73 1473

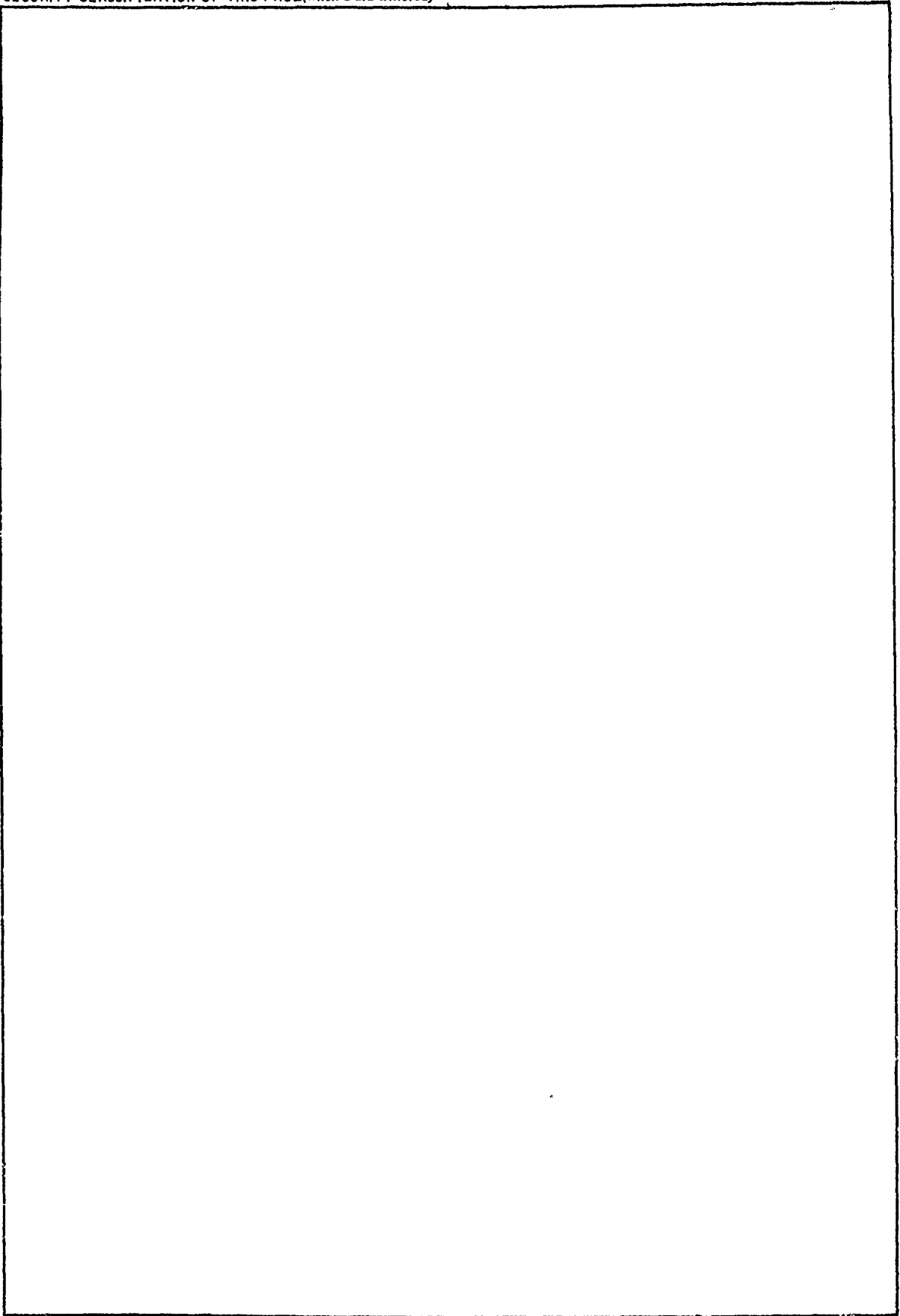
EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

78 12 26 008

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)



SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

FIGHTER INDEX OF THERMAL STRESS:  
RELATION TO WEATHER CONDITIONS  
AT ATC AND TAC BASES

INTRODUCTION

The Fighter Index of Thermal Stress (FITS) was developed to assist USAF commanders in minimizing the adverse effects of heat stress on aircrews during hot-weather flight operations. The mathematical derivation of FITS and the rationale for setting exposure limits appear in detail elsewhere (2). This report briefly describes the FITS concept, then presents data relating it to weather conditions at selected USAF bases.

DERIVATION OF TABLES

FITS was developed from the widely accepted Wet Bulb Globe Temperature (WBGT) (3), which yields a single value representing effective heat stress based on three weighted variables: air temperature, humidity, and radiant heating. Recent measurements of cockpit conditions show that during low-level flight (< 3000 ft, or 915 m, AGL), cockpit WBGT is directly related to ground WBGT (1). Several simplifying assumptions were made (2) to produce the following equation describing thermal conditions for cockpits of one- and two-place jet aircraft during low-level flight:

$$\text{FITS} = .83 T_{\text{pwb}} + .36 T_{\text{db}} + 5.04^{\circ}\text{C}$$

where  $T_{\text{pwb}}$  = psychrometric wet bulb temperature and  $T_{\text{db}}$  = dry bulb temperature, both measured at ground level and expressed in  $^{\circ}\text{C}$ . Psychrometric equations were used to produce FITS in table form (Tables 1A and 1B). The notes which appear at the bottom of both tables are an integral part of the concept.

Selection of exposure limits (Caution and Danger Zones) was a complex problem. Factors considered include aircrew age, physical fitness, heat acclimatization, clothing, and metabolic rate (2). The Caution Zone ( $32^{\circ}\text{C} \leq \text{FITS} < 38^{\circ}\text{C}$ ) includes conditions that should be physiologically compensable when adequate hydration is maintained. The Danger Zone ( $\text{FITS} \geq 38^{\circ}\text{C}$ ) produces progressive heat storage, with adverse effects on performance and on tolerance for other stresses such as acceleration and hypoxia.

TABLE 1A. FIGHTER INDEX OF THERMAL STRESS IN °C (LOW-LEVEL FLIGHT, CLEAR SKY TO LIGHT OVERCAST)

Instructions: Enter with local dry bulb temperature and dewpoint temperature; at intersection read FITS value and zone. Applies only to lightweight flight clothing. See notes for zone explanation. The X denotes combinations above saturation temperature.

| Dry Bulb<br>Temp.<br>(°C) | Zone                 | Dewpoint Temperature (°C) |    |    |    |    |     |     |     |    |     |
|---------------------------|----------------------|---------------------------|----|----|----|----|-----|-----|-----|----|-----|
|                           |                      | ≤0                        | 5  | 10 | 15 | 20 | 25  | 30  | 35  | 40 | ≥45 |
| 20.0                      | Normal               | 21                        | 22 | 24 | 26 | 29 | X   | X   | X   | X  | X   |
| 22.5                      |                      | 23                        | 24 | 26 | 28 | 30 | X   | X   | X   | X  | X   |
| 25.0                      |                      | 24                        | 26 | 27 | 29 | 31 | 35  | X   | X   | X  | X   |
| 27.5                      |                      | 26                        | 27 | 29 | 31 | 33 | 36  | X   | X   | X  | X   |
| 30.0                      |                      | 28                        | 29 | 31 | 32 | 35 | 37  | 41  | X   | X  | X   |
| 32.5                      |                      | 29                        | 31 | 32 | 34 | 36 | 39  | 42  | X   | X  | X   |
| 35.0                      | Caution <sup>1</sup> | 31                        | 32 | 34 | 36 | 37 | 40  | 43  | 46  | X  | X   |
| 37.5                      |                      | 33                        | 34 | 35 | 37 | 39 | 42  | 45  | 48* | X  | X   |
| 40.0                      |                      | 34                        | 35 | 37 | 39 | 41 | 43  | 46  | 49* | 52 | X   |
| 42.5                      |                      | 36                        | 37 | 38 | 40 | 42 | 44  | 47* | 50  | 54 | X   |
| 45.0                      | Danger <sup>2</sup>  | 37                        | 39 | 40 | 41 | 43 | 46  | 48* | 52  | 55 | 58  |
| 47.5                      |                      | 39                        | 40 | 41 | 43 | 45 | 47* | 50  | 53  | 56 | 59  |
| 50.0                      |                      | 41                        | 42 | 43 | 44 | 46 | 48* | 51  | 54  | 57 | 61  |

<sup>1</sup>Caution Zone: (1) Be aware of heat stress.  
(2) Limit ground period (preflight and ground standby) to 90 min.  
(3) Minimum 2-hr recovery between flights.

<sup>2</sup>Danger Zone: (1) Cancel low-level flights (below 915 m AGL).  
(2) Limit ground period to 45 min.  
(3) Minimum 2-hr recovery between flights.

\*When value is greater than 46, cancel all nonessential flights.

Comments:

Observe the following general hot-weather precautions: (1) Allow time for acclimatization to hot weather; avoid extreme efforts on the first several days of exposure. (2) Try to drink more water than thirst dictates; water intake is vital to sweat secretion, the body's main defense against heat.

This table is not to be used when CD, immersion, or arctic flight equipment is worn.

TABLE 1B. FIGHTER INDEX OF THERMAL STRESS IN °F (LOW-LEVEL FLIGHT, CLEAR SKY TO LIGHT OVERCAST)

Instructions: Enter with local dry bulb temperature and dewpoint temperature; at intersection read FITS value and zone. Applies only to lightweight flight clothing. See notes for zone explanation. The X denotes combinations above saturation temperature.

| Dry Bulb<br>Temp.<br>(°F) | Zone                 | Dewpoint Temperature (°F) |     |     |     |     |      |      |      |      |
|---------------------------|----------------------|---------------------------|-----|-----|-----|-----|------|------|------|------|
|                           |                      | ≤30                       | 40  | 50  | 60  | 70  | 80   | 90   | 100  | ≥110 |
| 70                        | Normal               | 70                        | 73  | 76  | 81  | 86  | X    | X    | X    | X    |
| 75                        |                      | 74                        | 77  | 80  | 84  | 89  | X    | X    | X    | X    |
| 80                        |                      | 77                        | 80  | 83  | 87  | 92  | 98   | X    | X    | X    |
| 85                        |                      | 81                        | 83  | 86  | 90  | 95  | 101  | X    | X    | X    |
| 90                        |                      | 84                        | 87  | 90  | 93  | 98  | 104  | 110  | X    | X    |
| 95                        | Caution <sup>1</sup> | 88                        | 90  | 93  | 96  | 101 | 108  | 112  | X    | X    |
| 100                       |                      | 91                        | 93  | 96  | 99  | 104 | 109  | 115  | 122* | X    |
| 105                       |                      | 94                        | 96  | 99  | 102 | 107 | 112  | 118* | 124  | X    |
| 110                       |                      | 97                        | 99  | 102 | 105 | 109 | 114  | 120* | 126  | 133  |
| 115                       | Danger <sup>2</sup>  | 100                       | 102 | 105 | 109 | 112 | 117* | 123  | 129  | 136  |
| 120                       |                      | 104                       | 105 | 108 | 111 | 115 | 120* | 125  | 131  | 138  |

<sup>1</sup>Caution Zone: (1) Be aware of heat stress.  
(2) Limit ground period (preflight and ground standby) to 90 min.  
(3) Minimum 2-hr recovery between flights.

<sup>2</sup>Danger Zone: (1) Cancel low-level flights (below 3,000 ft AGL).  
(2) Limit ground period to 45 min.  
(3) Minimum 2-hr recovery between flights.

\*When value is greater than 115, cancel all nonessential flights.

Comments:

Observe the following general hot-weather precautions: (1) Allow time for acclimatization to hot weather; avoid extreme efforts on the first several days of exposure. (2) Try to drink more water than thirst dictates; water intake is vital to sweat secretion, the body's main defense against heat.

This table is not to be used when CD, immersion, or arctic flight equipment is worn.

|                                 |  |
|---------------------------------|--|
| ACCESSION for                   |  |
| NTIS                            | Wire Section <input checked="" type="checkbox"/> |
| DDP                             | File Section <input type="checkbox"/>            |
| OTHER                           | <input type="checkbox"/>                         |
| SY                              |  |
| DISTRIBUTION/AVAILABILITY NOTES |  |
| SPECIAL                         |  |
| R12314                          |  |

## WEATHER DATA

FITS was designed for the types of aircraft flown primarily by the Air Training Command (ATC) and the Tactical Air Command (TAC). To assess the impact of FITS guidelines on USAF flying operations, weather data were examined for the 30 ATC and TAC flying bases located in the continental United States. Hourly  $T_{db}$  and  $T_{wb}$  records for a 6- to 12-year period were used to determine for each base the percentage of FITS readings falling in the Caution and Danger Zones for each hour of the day and month of the year.

Results are summarized in Table 2, and detailed data for each base appear in Appendix A. FITS applies only to the hours between local sunrise and sunset, since the index assumes the contribution of radiant heat due to sunlight.

## DISCUSSION AND CONCLUSION

The majority of ATC and TAC bases are located in the southern United States. At many of these bases on summer days, Caution readings are the rule, with a significant number of hours in the Danger Zone. Taking Bergstrom AFB as an example, planners there can expect Caution conditions during most daylight hours from May through September, with Danger readings commonly occurring between noon and sunset, June through September.

This information can be used in briefing all operations and flying personnel on the problems and hazards of heat stress, together with proper preventive measures. Schedules can be planned to avoid low-level flights and repeat missions by the same persons during the hottest weather.

It is recommended that each base set up a hot-weather alert system similar to that used for windchill at northern bases during the winter months. The Operations Office would then monitor weather forecasts to predict conditions in the FITS Caution and Danger Zones. Local temperature and humidity readings would also be followed in real time so that operations could be modified to prevent undue heat stress or to take advantage of unexpectedly cool conditions. The FITS chart should be posted in all flight-planning areas, with supervisory personnel responsible for enforcement of preventive measures.

In conclusion, FITS is designed as an aid to USAF personnel in planning and carrying out low-level fighter/trainer missions in hot weather, while minimizing the heat-stress effects which are often subtle but are nevertheless real. A study of USAF data shows that accident rates for fighter aircraft peak in summer, when heat may be a contributing factor (4). Data presented here should help to ameliorate any such effect.



TABLE 2. FITS WEATHER-DATA SUMMARY FOR 30 ATC AND TAC BASES

| Base                   | Data years<br>First - Last | No. of months* |    |    |
|------------------------|----------------------------|----------------|----|----|
|                        |                            | C5             | D1 | D5 |
| Bergstrom AFB TX       | 1966-75                    | 7              | 4  | 2  |
| Cannon AFB NM          | 1966-75                    | 3              | 0  | 0  |
| Chanute AFB IL         | 1951-60                    | 4              | 3  | 0  |
| Columbus AFB MS        | 1966-76                    | 5              | 3  | 1  |
| Craig AFB AL           | 1966-75                    | 7              | 4  | 2  |
| Davis-Monthan AFB AZ   | 1966-75                    | 4              | 0  | 0  |
| Eglin AFB FL           | 1966-75                    | 6              | 4  | 2  |
| England AFB LA         | 1966-75                    | 7              | 4  | 2  |
| George AFB CA          | 1966-76                    | 4              | 0  | 0  |
| Holloman AFB NM        | 1966-75                    | 3              | 0  | 0  |
| Homestead AFB FL       | 1966-75                    | 12             | 3  | 0  |
| Keesler AFB MS         | 1955-64                    | 7              | 4  | 2  |
| Langley AFB VA         | 1966-76                    | 4              | 3  | 0  |
| Laughlin AFB TX        | 1954-62                    | 7              | 4  | 1  |
| Lowry AFB CO           | 1966-75                    | 0              | 0  | 0  |
| Luke AFB AZ            | 1966-75                    | 5              | 4  | 2  |
| MacDill AFB FL         | 1966-76                    | 9              | 4  | 2  |
| Mather AFB CA          | 1966-76                    | 5              | 0  | 0  |
| Moody AFB GA           | 1966-75                    | 7              | 3  | 0  |
| Mountain Home AFB ID   | 1966-76                    | 2              | 0  | 0  |
| Myrtle Beach AFB SC    | 1966-76                    | 6              | 4  | 2  |
| Nellis AFB NV          | 1970-76                    | 4              | 3  | 0  |
| Randolph AFB TX        | 1970-76                    | 7              | 4  | 0  |
| Reese AFB TX           | 1950-60                    | 4              | 0  | 0  |
| Seymour Johnson AFB NC | 1966-76                    | 5              | 3  | 1  |
| Shaw AFB SC            | 1966-76                    | 5              | 3  | 1  |
| Sheppard AFB TX        | 1970-76                    | 6              | 4  | 3  |
| Vance AFB OK           | 1966-76                    | 5              | 3  | 0  |
| Webb AFB TX            | 1966-75                    | 5              | 0  | 0  |
| Williams AFB AZ        | 1966-76                    | 5              | 3  | 0  |

\*Number of months having > 5 days in Caution Zone (C5), > 1 day in Danger Zone (D1), and > 5 days in Danger Zone (D5).

#### ACKNOWLEDGMENT

The authors wish to thank the following for their assistance with this project: Capt D. E. Guilbert and Capt D. J. Greene, Office of the Staff Meteorologist, Aeronautical Systems Division; Capt L. Cork, USAF Environmental Technical Applications Center; TSgt Antonio Sustaita, Sr., and Mr. George Ozuna, USAF School of Aerospace Medicine.

#### REFERENCES

1. Harrison, M. H., et al. Relationship between ambient, cockpit, and pilot temperatures during routine air operations. *Aviat Space Environ Med* 49:5-13 (1978).
2. Stribley, R. F., and S. A. Nunneley. Fighter index of thermal stress: Development of interim guidance for hot-weather USAF operations. SAM-TR-78-6, Feb 1978.
3. Yaglou, C. P., and D. Minard. Control of heat casualties at military training centers. *Arch Ind Health* 16:302-316 (1957).
4. Zeller, A. F. Curves in your future. USAF Inspection and Safety Center, USAF Safety Officer's Study Kit, pp. 7-13, Nov 1972.

## APPENDIX A

Graphs show frequency of FITS Caution and Danger Zone weather conditions at the following 30 USAF bases:

| <u>BASE NAME</u> | <u>STATE</u>   |
|------------------|----------------|
| Bergstrom        | Texas          |
| Cannon           | New Mexico     |
| Chanute          | Illinois       |
| Columbus         | Mississippi    |
| Craig            | Alabama        |
| Davis-Monthan    | Arizona        |
| Eglin            | Florida        |
| England          | Louisiana      |
| George           | California     |
| Holloman         | New Mexico     |
| Homestead        | Florida        |
| Keesler          | Mississippi    |
| Langley          | Virginia       |
| Laughlin         | Texas          |
| Lowry            | Colorado       |
| Luke             | Arizona        |
| MacDill          | Florida        |
| Mather           | California     |
| Moody            | Georgia        |
| Mountain Home    | Idaho          |
| Myrtle Beach     | South Carolina |
| Nellis           | Nevada         |
| Randolph         | Texas          |
| Reese            | Texas          |
| Seymour Johnson  | North Carolina |
| Shaw             | South Carolina |
| Sheppard         | Texas          |
| Vance            | Oklahoma       |
| Webb             | Texas          |
| Williams         | Arizona        |

CANNON AFB NM

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

T I N F

H H 2 F

J E M A N J J A S O N D

# III:ION

FIGHTER INDEX OF THERMAL STRESS (FITS): AVERAGE  
CONDITIONS F<sup>2</sup> TIME OF DAY (LOCAL STD) AND MONTH OF YEAR.

KEY: . > 5 DAYS/MONTH IN CAUTION ZONE  
0 > 1 DAY / MONTH IN DANGER ZONE  
Ø > 5 DAYS/MONTH IN DANGER ZONE

# CHANUTE AFB IL

0  
1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23

TIME

. . . . .  
. . . . .  
. . . . .  
. . . . .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .

J F M A M J J A S O N D

MONTH

# COLUMBUS AFB MS

0  
1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23

TIME

. . . . .  
. . . . .  
. . . . .  
. . . . .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .  
0 0 0 0 .

J F M A M J J A S O N D

MONTH

FIGHTER INDEX OF THERMAL STRESS (FITS): AVERAGE  
CONDITIONS BY TIME OF DAY (LOCAL STD) AND MONTH OF YEAR.

KEY: . > 5 DAYS/MONTH IN CAUTION ZONE  
0 > 1 DAY/MONTH IN DANGER ZONE  
Ø > 5 DAYS/MONTH IN DANGER ZONE

TIME.

## MENTOR

FIGHTER INDEX OF THERMAL STRESS (FITS): AVERAGE  
CONDITIONS BY TIME OF DAY (LOCAL STD) AND MONTH OF YEAR.

KEY: • > 5 DAYS/MONTH IN CAUTION ZONE  
 0 > 1 DAY / MONTH IN DANGER ZONE  
 Ø > 5 DAYS/MONTH IN DANGER ZONE

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Figure 1 shows a set of 19 points labeled  $g_0$  through  $g_{18}$ . The points are arranged in a grid-like pattern. The labels are as follows:

- $g_0$  is at the top left.
- $g_1$  is at the top left, below  $g_0$ .
- $g_2$  is at the top left, below  $g_1$ .
- $g_3$  is at the top left, below  $g_2$ .
- $g_4$  is at the top left, below  $g_3$ .
- $g_5$  is at the top left, below  $g_4$ .
- $g_6$  is at the top left, below  $g_5$ .
- $g_7$  is at the top left, below  $g_6$ .
- $g_8$  is at the top left, below  $g_7$ .
- $g_9$  is at the top left, below  $g_8$ .
- $g_{10}$  is at the top left, below  $g_9$ .
- $g_{11}$  is at the top left, below  $g_{10}$ .
- $g_{12}$  is at the top left, below  $g_{11}$ .
- $g_{13}$  is at the top left, below  $g_{12}$ .
- $g_{14}$  is at the top left, below  $g_{13}$ .
- $g_{15}$  is at the top left, below  $g_{14}$ .
- $g_{16}$  is at the top left, below  $g_{15}$ .
- $g_{17}$  is at the top left, below  $g_{16}$ .
- $g_{18}$  is at the top left, below  $g_{17}$ .
- $g_{19}$  is at the top left, below  $g_{18}$ .

## II. INTRODUCTION

ENGLAND AFB LA

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

II. 2. 1

J F N A N J J A S O N D  
MONTH

FIGHTER INDEX OF THERMAL STRESS (FITS): AVERAGE  
CONDITIONS BY TIME OF DAY (LOCAL STD) AND MONTH OF YEAR.

KEY: • > 5 DAYS/MONTH IN CAUTION ZONE  
0 > 1 DAY / MONTH IN DANGER ZONE  
Ø > 5 DAYS/MONTH IN DANGER ZONE

FOLLOMAN AFB mi

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

T I F

三三三

MONTH

# **LITIGATION**

FIGHTER INDEX OF THERMAL STRESS (FITS): AVERAGE  
CONDITIONS BY TIME OF DAY (LOCAL STD) AND MONTH OF YEAR.

KEY: • > 5 DAYS/MONTH IN CAUTION ZONE  
 0 > 1 DAY /MONTH IN DANGER ZONE  
 Ø > 5 DAYS/MONTH IN DANGER ZONE

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

11-11-2014

A rectangular array of dots arranged in 3 rows and 7 columns. The dots are black and evenly spaced.

U F M A M J J A S O N D  
MONTH

# ILLIUM



HOMESTEAD AFB FL

0 1 2 3 4 5 6 7 8 9  
10 11 12 13 14 15 16 17 18 19 20 21 22 23

FILE

TIME

MONTH  
J E F A R Y A S C H D

MONTH  
J F M A M J J A S O N D

FIGHTER INDEX OF THERMAL STRESS (FITS): AVERAGE CONDITIONS BY TIME OF DAY (LOCAL STD) AND MONTH OF YEAR.

KEY: • > 5 DAYS/MONTH IN CAUTION ZONE  
0 > 1 DAY / MONTH IN DANGER ZONE  
ø > 5 DAYS/MONTH IN DANGER ZONE

LAUGHLIN AFB TX

T I M E

J E M A M J J A S O N D

MONTH

FIGHTER INDEX OF THERMAL STRESS (FITS): AVERAGE  
CONDITIONS BY TIME OF DAY (LOCAL STD) AND MONTH OF YEAR.

KEY: . > 5 DAYS/MONTH IN CAUTION ZONE  
0 > 1 DAY /MONTH IN DANGER ZONE  
Ø > 5 DAYS/MONTH IN DANGER ZONE



MACDILL AFB FL

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

T I N F

JEFFREY J. JASON

## II. NOISE

FIGHTER INDEX OF THERMAL STRESS (FITS): AVERAGE CONDITIONS BY TIME OF DAY (LOCAL STD) AND MONTH OF YEAR.

KEY: . > 5 DAYS/MONTH IN CAUTION ZONE  
 0 > 1 DAY / MONTH IN DANGER ZONE  
 Ø > 5 DAYS/MONTH IN DANGER ZONE

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

FILE

THE AMERICAN JOURNAL

**MONTH**

| MOODY AFB GA            |      | MOUNTAIN HOME AFB ID    |      |
|-------------------------|------|-------------------------|------|
| C                       | TIME | C                       | TIME |
|                         |      |                         |      |
| 1                       |      | 1                       |      |
| 2                       |      | 2                       |      |
| 3                       |      | 3                       |      |
| 4                       |      | 4                       |      |
| 5                       |      | 5                       |      |
| 6                       |      | 6                       |      |
| 7                       |      | 7                       |      |
| 8                       |      | 8                       |      |
| 9                       |      | 9                       |      |
| 10                      |      | 10                      |      |
| 11                      |      | 11                      |      |
| 12                      |      | 12                      |      |
| 13                      |      | 13                      |      |
| 14                      |      | 14                      |      |
| 15                      |      | 15                      |      |
| 16                      |      | 16                      |      |
| 17                      |      | 17                      |      |
| 18                      |      | 18                      |      |
| 19                      |      | 19                      |      |
| 20                      |      | 20                      |      |
| 21                      |      | 21                      |      |
| 22                      |      | 22                      |      |
| 23                      |      | 23                      |      |
| J F M A M J J A S O N D |      | J F M A M J J A S O N D |      |

MONTH  
 FIGHTER INDEX OF THERMAL STRESS (FITS): AVERAGE  
 CONDITIONS BY TIME OF DAY (LOCAL STD) AND MONTH OF YEAR.  
 KEY: > 5 DAYS/MONTH IN CAUTION ZONE  
 0 > 1 DAY / MONTH IN DANGER ZONE  
 Ø > 5 DAYS/MONTH IN DANGER ZONE

# NELLIS AFB NV

0  
1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23

T  
I  
M  
E

# MYRTLE BEACH AFB SC

0  
1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23

T  
I  
M  
E

J F M A M J J A S O N D

MONTH

FIGHTER INDEX OF THERMAL STRESS (FITS): AVERAGE  
CONDITIONS BY TIME OF DAY (LOCAL STD) AND MONTH OF YEAR.

KEY: • > 5 DAYS/MONTH IN CAUTION ZONE  
0 > 1 DAY / MONTH IN DANGER ZONE  
Ø > 5 DAYS/MONTH IN DANGER ZONE

| RANDOLPH AFB TX         |  |  |  |  |  |  |  |  |  |  |  | REFSF AFB TX            |  |  |  |  |  |  |  |  |  |  |  |
|-------------------------|--|--|--|--|--|--|--|--|--|--|--|-------------------------|--|--|--|--|--|--|--|--|--|--|--|
| TIME                    |  |  |  |  |  |  |  |  |  |  |  | TIME                    |  |  |  |  |  |  |  |  |  |  |  |
| 0                       |  |  |  |  |  |  |  |  |  |  |  | 0                       |  |  |  |  |  |  |  |  |  |  |  |
| 1                       |  |  |  |  |  |  |  |  |  |  |  | 1                       |  |  |  |  |  |  |  |  |  |  |  |
| 2                       |  |  |  |  |  |  |  |  |  |  |  | 2                       |  |  |  |  |  |  |  |  |  |  |  |
| 3                       |  |  |  |  |  |  |  |  |  |  |  | 3                       |  |  |  |  |  |  |  |  |  |  |  |
| 4                       |  |  |  |  |  |  |  |  |  |  |  | 4                       |  |  |  |  |  |  |  |  |  |  |  |
| 5                       |  |  |  |  |  |  |  |  |  |  |  | 5                       |  |  |  |  |  |  |  |  |  |  |  |
| 6                       |  |  |  |  |  |  |  |  |  |  |  | 6                       |  |  |  |  |  |  |  |  |  |  |  |
| 7                       |  |  |  |  |  |  |  |  |  |  |  | 7                       |  |  |  |  |  |  |  |  |  |  |  |
| 8                       |  |  |  |  |  |  |  |  |  |  |  | 8                       |  |  |  |  |  |  |  |  |  |  |  |
| 9                       |  |  |  |  |  |  |  |  |  |  |  | 9                       |  |  |  |  |  |  |  |  |  |  |  |
| 10                      |  |  |  |  |  |  |  |  |  |  |  | 10                      |  |  |  |  |  |  |  |  |  |  |  |
| 11                      |  |  |  |  |  |  |  |  |  |  |  | 11                      |  |  |  |  |  |  |  |  |  |  |  |
| 12                      |  |  |  |  |  |  |  |  |  |  |  | 12                      |  |  |  |  |  |  |  |  |  |  |  |
| 13                      |  |  |  |  |  |  |  |  |  |  |  | 13                      |  |  |  |  |  |  |  |  |  |  |  |
| 14                      |  |  |  |  |  |  |  |  |  |  |  | 14                      |  |  |  |  |  |  |  |  |  |  |  |
| 15                      |  |  |  |  |  |  |  |  |  |  |  | 15                      |  |  |  |  |  |  |  |  |  |  |  |
| 16                      |  |  |  |  |  |  |  |  |  |  |  | 16                      |  |  |  |  |  |  |  |  |  |  |  |
| 17                      |  |  |  |  |  |  |  |  |  |  |  | 17                      |  |  |  |  |  |  |  |  |  |  |  |
| 18                      |  |  |  |  |  |  |  |  |  |  |  | 18                      |  |  |  |  |  |  |  |  |  |  |  |
| 19                      |  |  |  |  |  |  |  |  |  |  |  | 19                      |  |  |  |  |  |  |  |  |  |  |  |
| 20                      |  |  |  |  |  |  |  |  |  |  |  | 20                      |  |  |  |  |  |  |  |  |  |  |  |
| 21                      |  |  |  |  |  |  |  |  |  |  |  | 21                      |  |  |  |  |  |  |  |  |  |  |  |
| 22                      |  |  |  |  |  |  |  |  |  |  |  | 22                      |  |  |  |  |  |  |  |  |  |  |  |
| 23                      |  |  |  |  |  |  |  |  |  |  |  | 23                      |  |  |  |  |  |  |  |  |  |  |  |
| J F M A M J J A S O N D |  |  |  |  |  |  |  |  |  |  |  | J F M A M J J A S O N D |  |  |  |  |  |  |  |  |  |  |  |
| MONTH                   |  |  |  |  |  |  |  |  |  |  |  | MONTH                   |  |  |  |  |  |  |  |  |  |  |  |

FIGHTER INDEX OF THERMAL STRESS (FITS): AVERAGE  
CONDITIONS BY TIME OF DAY (LOCAL STD) AND MONTH OF YEAR.

KEY: • > 5 DAYS/MONTH IN CAUTION ZONE  
0 > 1 DAY / MONTH IN DANGER ZONE  
Ø > 5 DAYS/MONTH IN DANGER ZONE

| SEYMOUR JOHNSON AFB NC  |  |  |  |  |  |  |  |  |  |  |  | SHAW AFB SC             |  |  |  |  |  |  |  |  |  |  |  |
|-------------------------|--|--|--|--|--|--|--|--|--|--|--|-------------------------|--|--|--|--|--|--|--|--|--|--|--|
| TIME                    |  |  |  |  |  |  |  |  |  |  |  | TIME                    |  |  |  |  |  |  |  |  |  |  |  |
| 0                       |  |  |  |  |  |  |  |  |  |  |  | 0                       |  |  |  |  |  |  |  |  |  |  |  |
| 1                       |  |  |  |  |  |  |  |  |  |  |  | 1                       |  |  |  |  |  |  |  |  |  |  |  |
| 2                       |  |  |  |  |  |  |  |  |  |  |  | 2                       |  |  |  |  |  |  |  |  |  |  |  |
| 3                       |  |  |  |  |  |  |  |  |  |  |  | 3                       |  |  |  |  |  |  |  |  |  |  |  |
| 4                       |  |  |  |  |  |  |  |  |  |  |  | 4                       |  |  |  |  |  |  |  |  |  |  |  |
| 5                       |  |  |  |  |  |  |  |  |  |  |  | 5                       |  |  |  |  |  |  |  |  |  |  |  |
| 6                       |  |  |  |  |  |  |  |  |  |  |  | 6                       |  |  |  |  |  |  |  |  |  |  |  |
| 7                       |  |  |  |  |  |  |  |  |  |  |  | 7                       |  |  |  |  |  |  |  |  |  |  |  |
| 8                       |  |  |  |  |  |  |  |  |  |  |  | 8                       |  |  |  |  |  |  |  |  |  |  |  |
| 9                       |  |  |  |  |  |  |  |  |  |  |  | 9                       |  |  |  |  |  |  |  |  |  |  |  |
| 10                      |  |  |  |  |  |  |  |  |  |  |  | 10                      |  |  |  |  |  |  |  |  |  |  |  |
| 11                      |  |  |  |  |  |  |  |  |  |  |  | 11                      |  |  |  |  |  |  |  |  |  |  |  |
| 12                      |  |  |  |  |  |  |  |  |  |  |  | 12                      |  |  |  |  |  |  |  |  |  |  |  |
| 13                      |  |  |  |  |  |  |  |  |  |  |  | 13                      |  |  |  |  |  |  |  |  |  |  |  |
| 14                      |  |  |  |  |  |  |  |  |  |  |  | 14                      |  |  |  |  |  |  |  |  |  |  |  |
| 15                      |  |  |  |  |  |  |  |  |  |  |  | 15                      |  |  |  |  |  |  |  |  |  |  |  |
| 16                      |  |  |  |  |  |  |  |  |  |  |  | 16                      |  |  |  |  |  |  |  |  |  |  |  |
| 17                      |  |  |  |  |  |  |  |  |  |  |  | 17                      |  |  |  |  |  |  |  |  |  |  |  |
| 18                      |  |  |  |  |  |  |  |  |  |  |  | 18                      |  |  |  |  |  |  |  |  |  |  |  |
| 19                      |  |  |  |  |  |  |  |  |  |  |  | 19                      |  |  |  |  |  |  |  |  |  |  |  |
| 20                      |  |  |  |  |  |  |  |  |  |  |  | 20                      |  |  |  |  |  |  |  |  |  |  |  |
| 21                      |  |  |  |  |  |  |  |  |  |  |  | 21                      |  |  |  |  |  |  |  |  |  |  |  |
| 22                      |  |  |  |  |  |  |  |  |  |  |  | 22                      |  |  |  |  |  |  |  |  |  |  |  |
| 23                      |  |  |  |  |  |  |  |  |  |  |  | 23                      |  |  |  |  |  |  |  |  |  |  |  |
| J F M A M J J A S O N D |  |  |  |  |  |  |  |  |  |  |  | J F M A M J J A S O N D |  |  |  |  |  |  |  |  |  |  |  |
| MONTH                   |  |  |  |  |  |  |  |  |  |  |  | MONTH                   |  |  |  |  |  |  |  |  |  |  |  |

FIGHTER INDEX OF THERMAL STRESS (FITS): AVERAGE  
CONDITIONS BY TIME OF DAY (LOCAL STD) AND MONTH OF YEAR.

KEY: . > 5 DAYS/MONTH IN CAUTION ZONE  
0 > 1 DAY/MONTH IN DANGER ZONE  
Ø > 5 DAYS/MONTH IN DANGER ZONE



FFY: . > 5 DAYS/MONTH IN CAUTION ZONE  
0 > 1 DAY / MONTH IN DANGER ZONE  
Ø > 5 DAYS/MONTH IN DANGER ZONE

WILLIAMS AFB, AZ

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

TIME

A 5x10 grid of dots. The dots are arranged in a pattern that resembles a stylized letter 'A' or a similar shape. The top row has 10 dots. The second row has 9 dots, with the middle dot missing. The third row has 8 dots, with the two middle dots missing. The fourth row has 7 dots, with the three middle dots missing. The fifth row has 6 dots, with the four middle dots missing.

J F M A M J J A S O N D

**MONTH:**

FIGHTER INDEX OF THERMAL STRESS (FITS): AVERAGE CONDITIONS BY TIME OF DAY (LOCAL STD) AND MONTH OF YEAR.

KEY: .> 5 DAYS/MONTH IN CAUTION ZONE  
0> 1 DAY /MONTH IN DANGER ZONE  
ø> 5 DAYS/MONTH IN DANGER ZONE